Status at NCEP to Improve the Stratosphere in Reanalysis

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Issues in the Stratosphere in Reanalysis

- All Reanalyses
  - Capturing the QBO transitions W>E and E>W when they occur in nature.
  - Transition from TOVS(SSU+MSU) to ATOVS(AMSU) in 1998.

- Specific to CFSR:
  - Bias correction of SSU channel 3 results in jumps at beginning of each stream.
  - Poor representation of QBO in 1980's
  - Poor representation of SAO
  - Warm bias in upper stratosphere
  - CFSR did not assimilate AMSU Ch 14
  - Polar temperature amplitude inconsistent with other reanalyses
  - Repeating seasonal cycle in O3MR above 5 hPa
  - Poor specific humidity above the tropopause

Issues addressed

- Elimination of bias correction of SSU ch 3 and AMUS ch 14.
- Assimilation of AMSU ch 14 post November 1998
- Tests to see if using Hybrid EnKF improves capturing the QBO vs 1 member 3D-var.
  - This along with other strategies to spread or use radiosonde information
  - Use of rocketsonde soundings found to improve QBO in 1980's

Tests Performed this Past Year

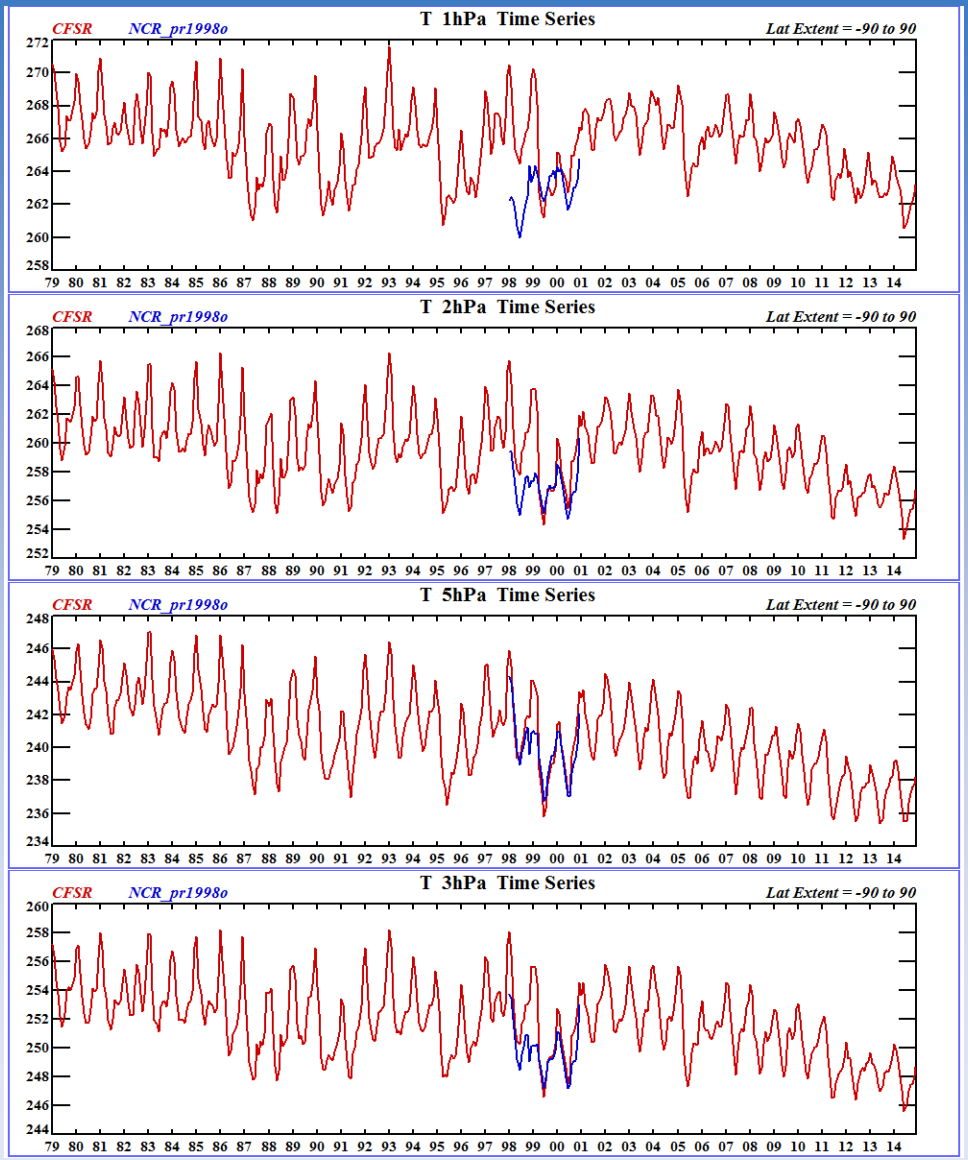
- Comparisons of tests with AMSU ch 14 not bias corrected vs CFSR (which did not assimilate AMSU ch 14)
- SSU to AMSU transition tests
  - Immediate switch from SSU to AMSU (Cntl)
  - Assimilation of SSU + AMSU for a period of time
  - No switch away from SSU (not assimilating AMSU ch 9-14)
- Tests to see the effect of not bias correcting AMSU ch 13&14.
- Tests to understand the impacts of assimilation of ozone vs using ozone climatology
- Tests to understand what is driving the seasonal cycle of O3MR in the upper stratosphere.

Comparison of pr1998o vs CFSR Temperatures

- **After transition from TOVS to ATOVS in late 1998, CFSR did not assimilate AMSU ch 14.**
- **Pr1998o replicated the TOVS to ATOVS transition in late 1998, but does assimilate AMSU ch 14 and does not bias correct it.**

Comparison of CFSR with Test run assimilating AMSU Ch 14

Not bias correcting the SSU keeps the Temps lower pre-1999.



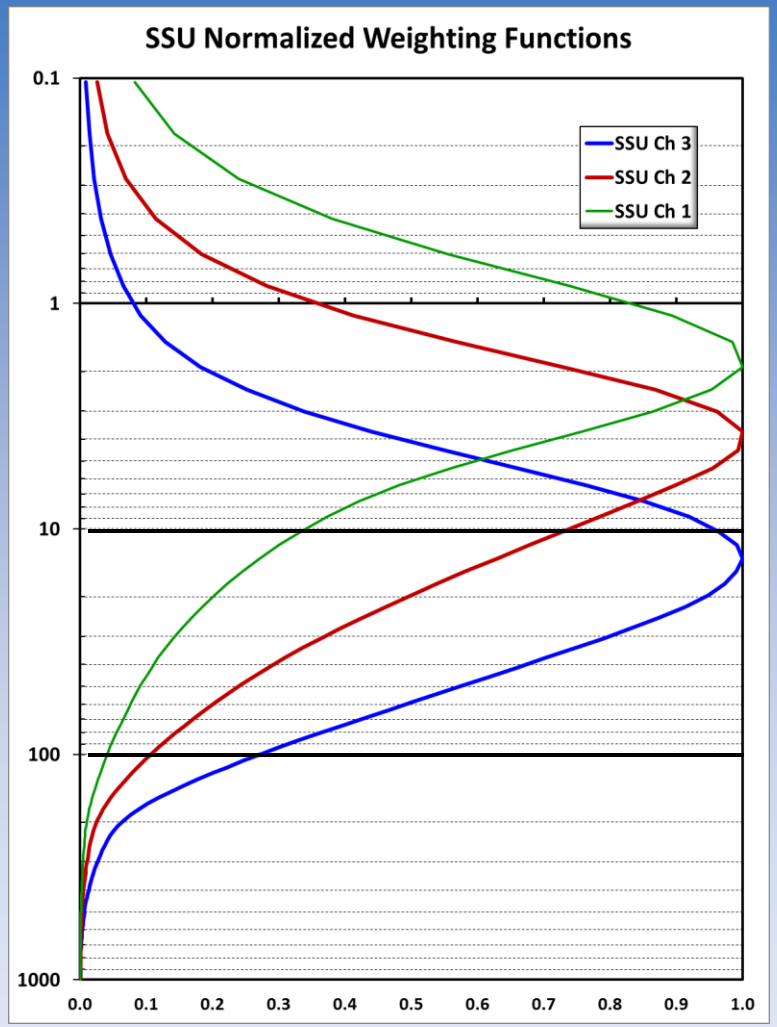
Temps from pr1998o agree very well with MERRA (trust me).

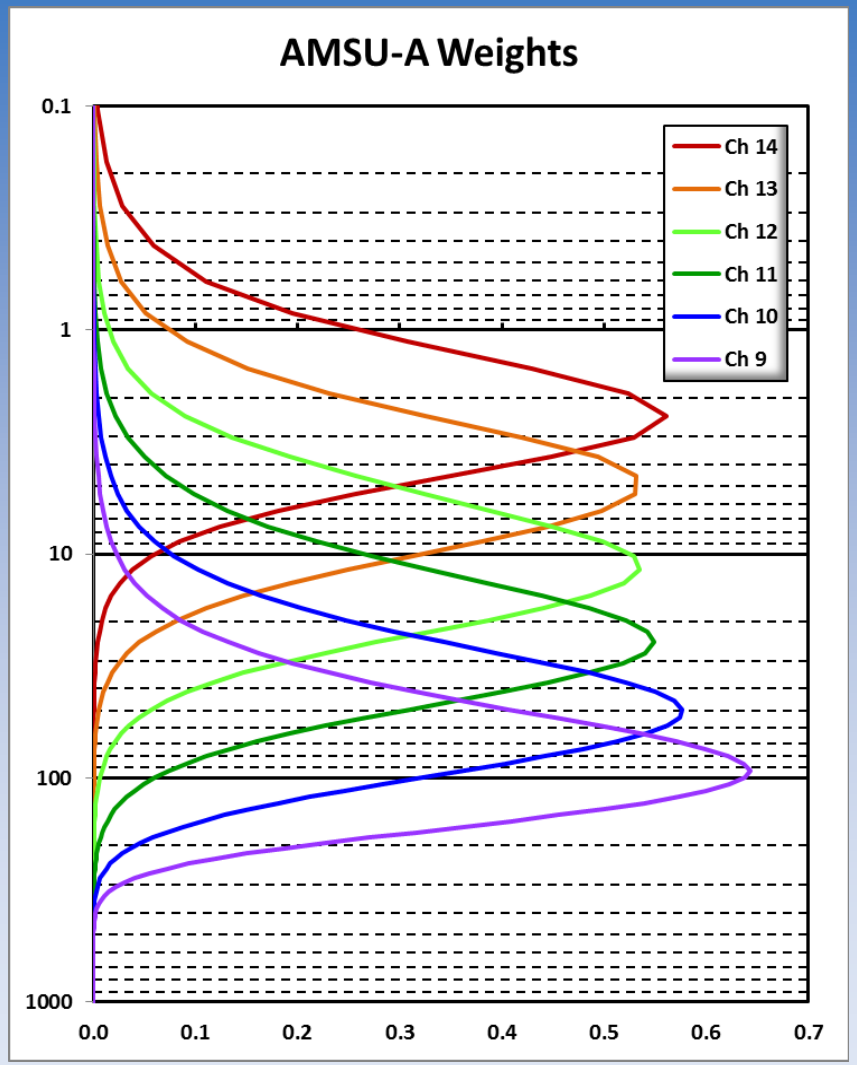
Should extend run to see how annual temp amplitude changes.

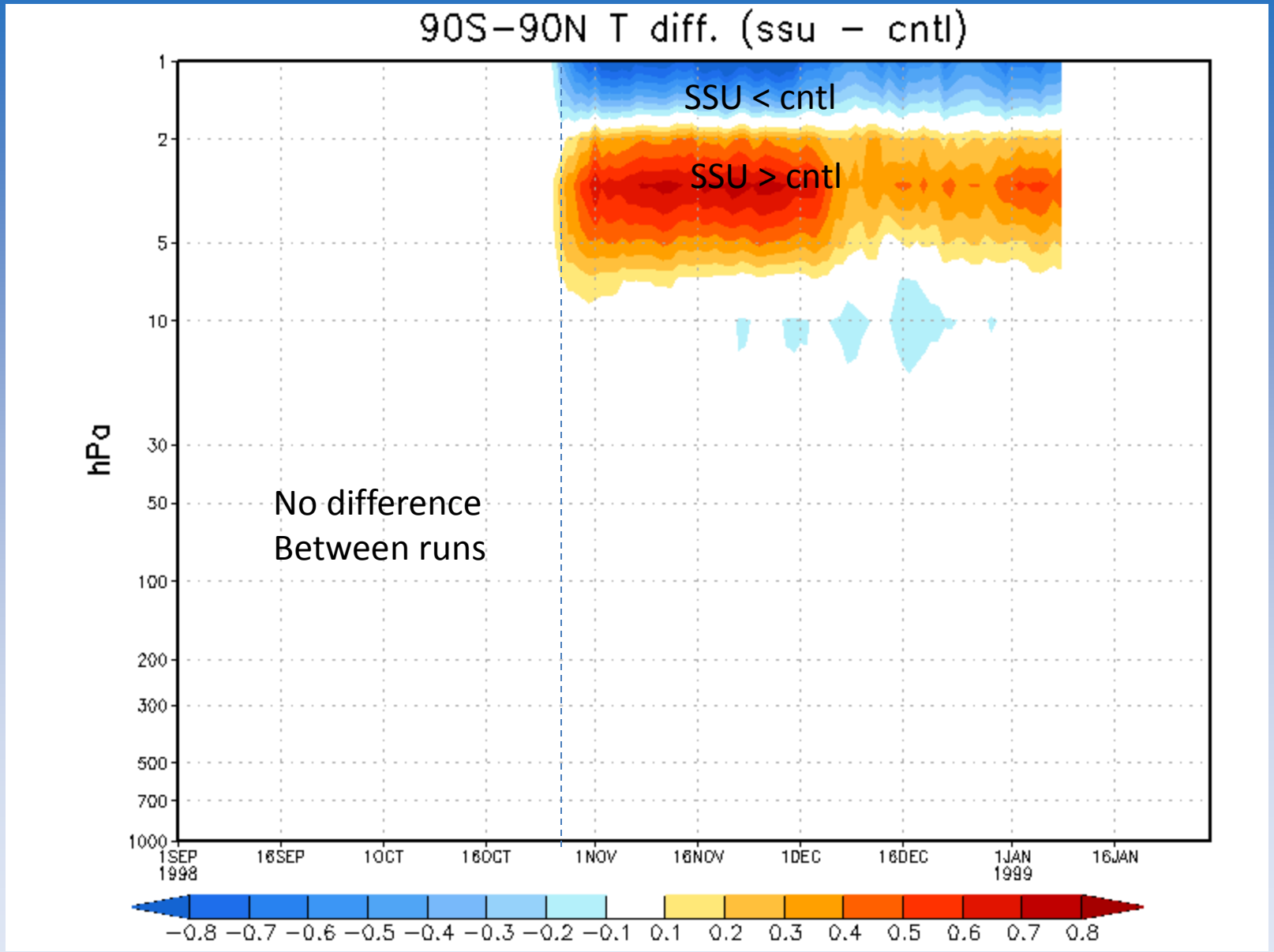
Impacts of Keeping SSU Data after AMSU

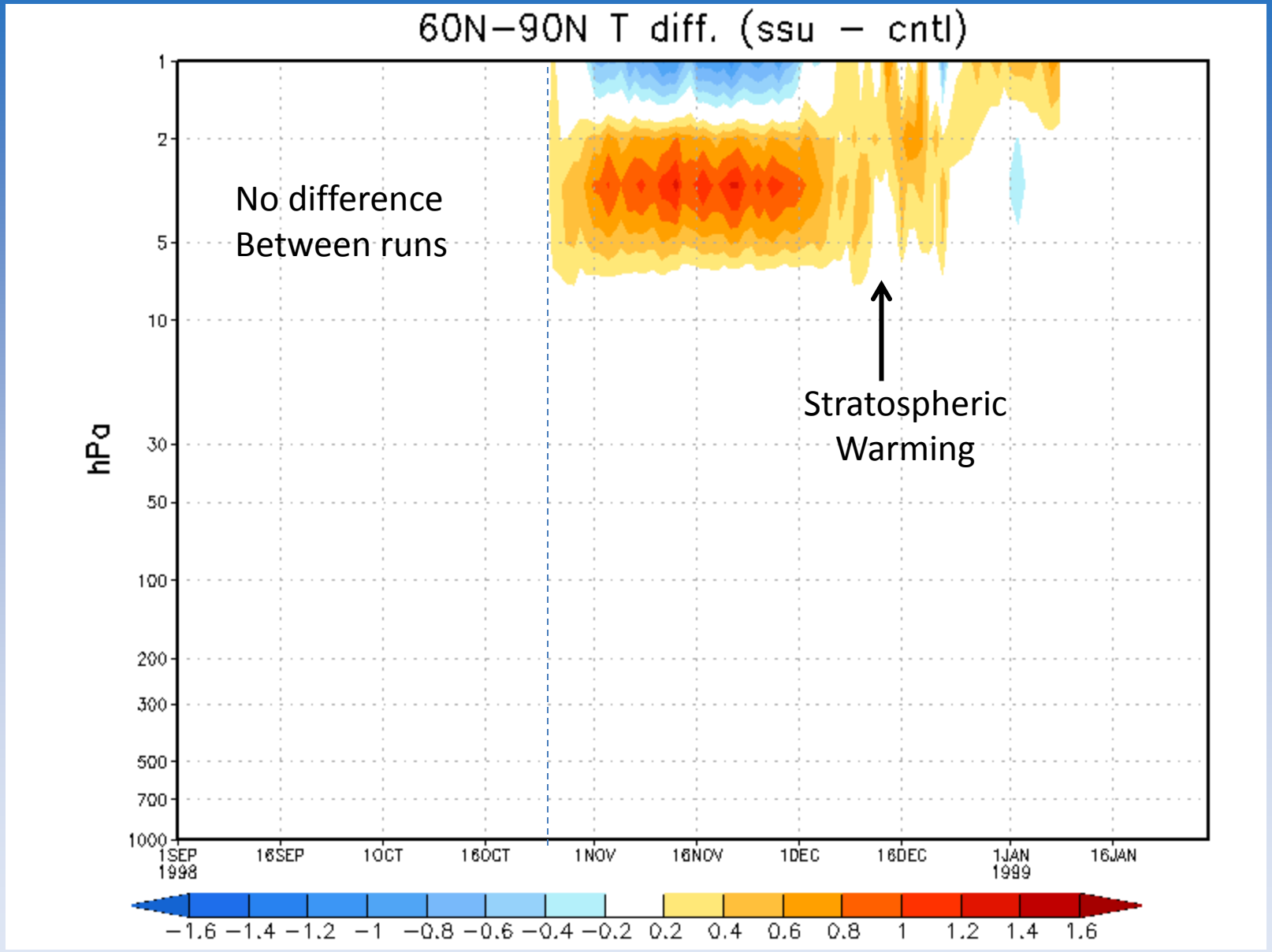
- **Control run (cntl): 3DVar, SSU is not used after AMSU starts in 10/26/1998**
- **Experiment run (ssu): 3DVar, SSU is kept after AMSU starts. Initiated from 09/01/1998**
- **Ozone is assimilated in both cntl and ssu experiments**

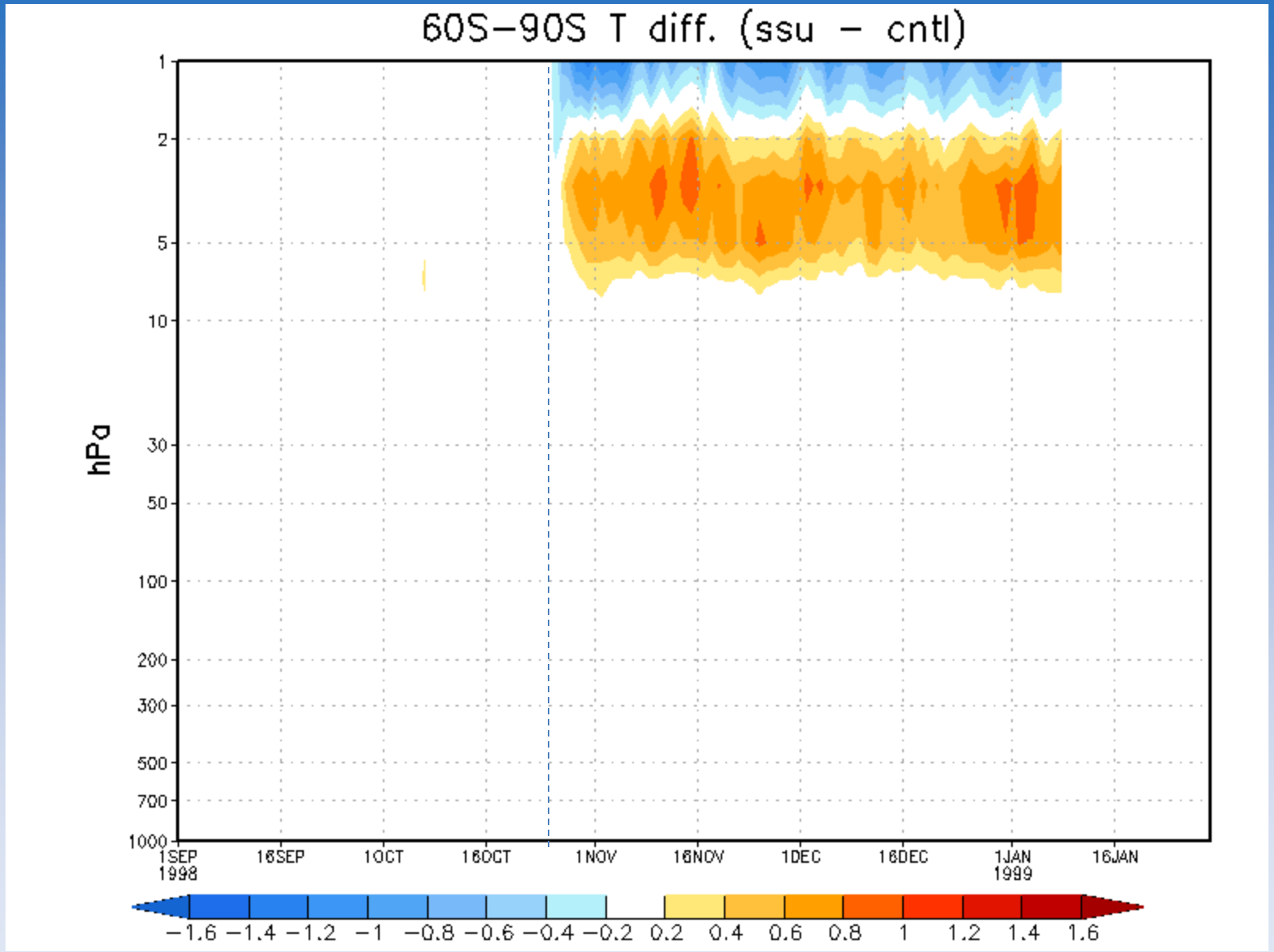
SSU and AMSU Weighting Functions

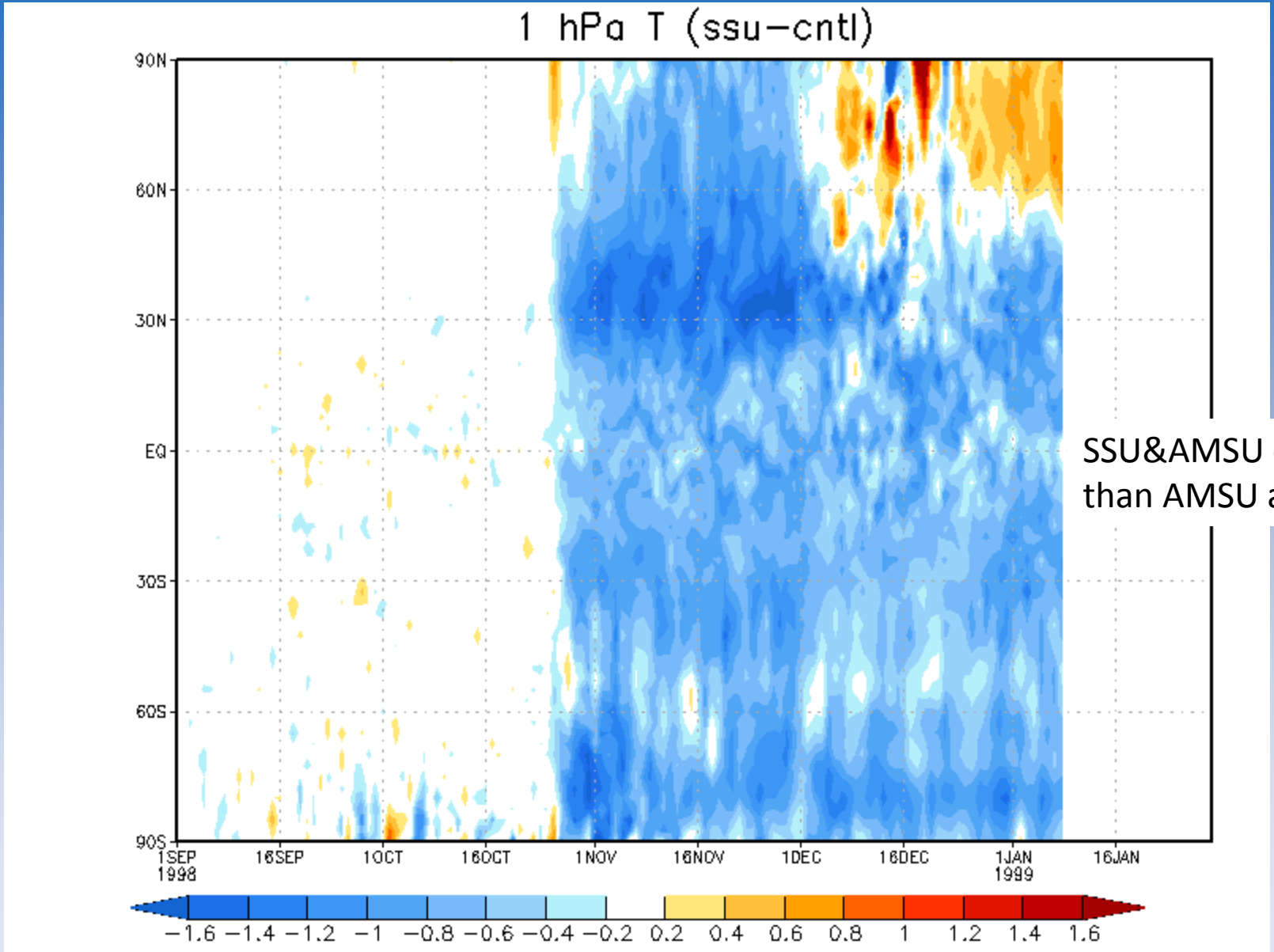




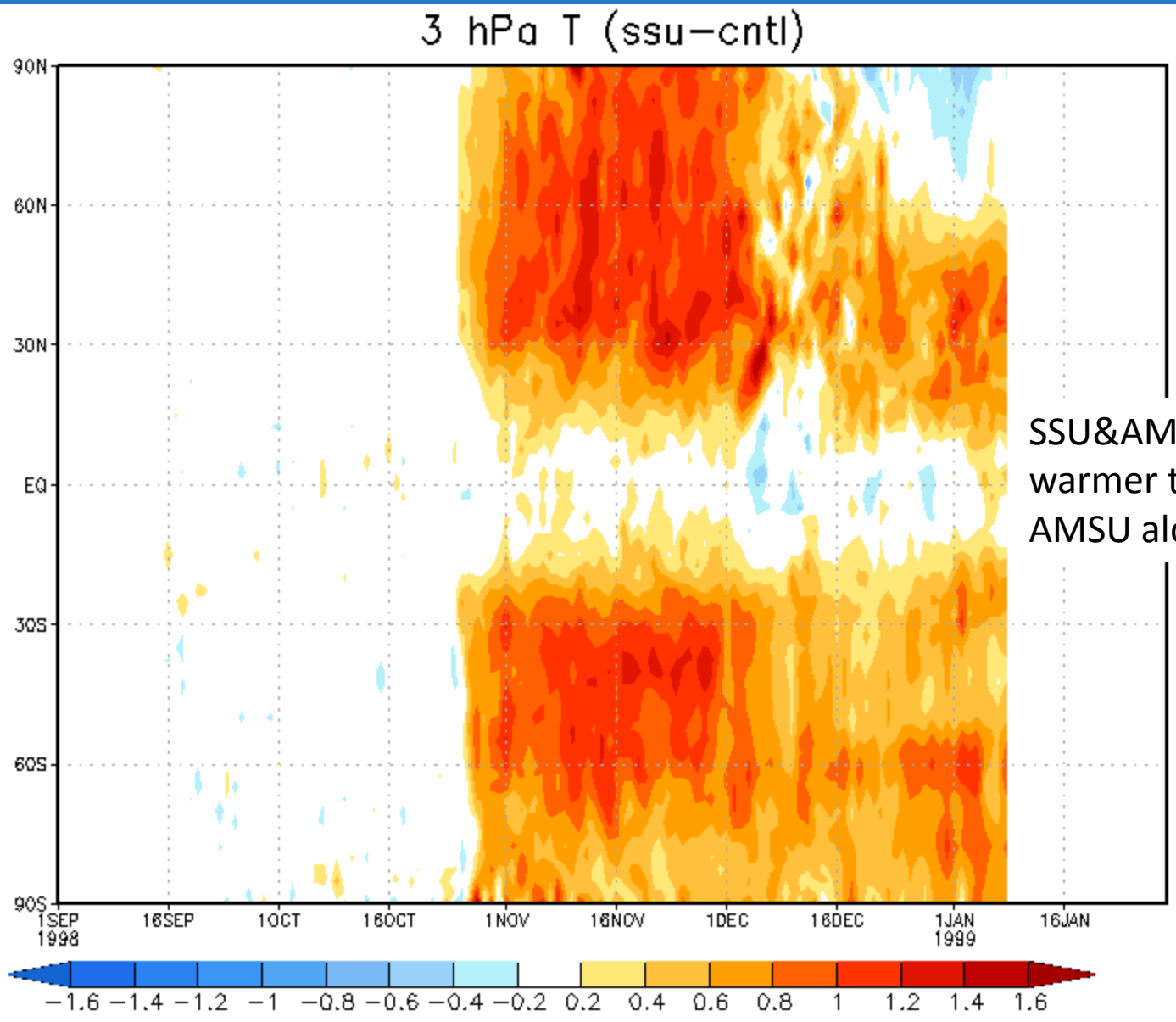

90S–90N T diff. (ssu – cntl)
SSU < cntl
SSU > cntl
No difference
Between runs
hPa
1
2
5
10
30
50
100
200
300
500
700
1000
1SEP 1998
16SEP
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC
1JAN 1999
16JAN
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8


60N–90N T diff. (ssu – cntl)
No difference
Between runs
Stratospheric
Warming
hPa
1
2
5
10
30
50
100
200
300
500
700
1000
1SEP
1998
16SEP
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC
1JAN
1999
16JAN
−1.6 −1.4 −1.2 −1 −0.8 −0.6 −0.4 −0.2 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6

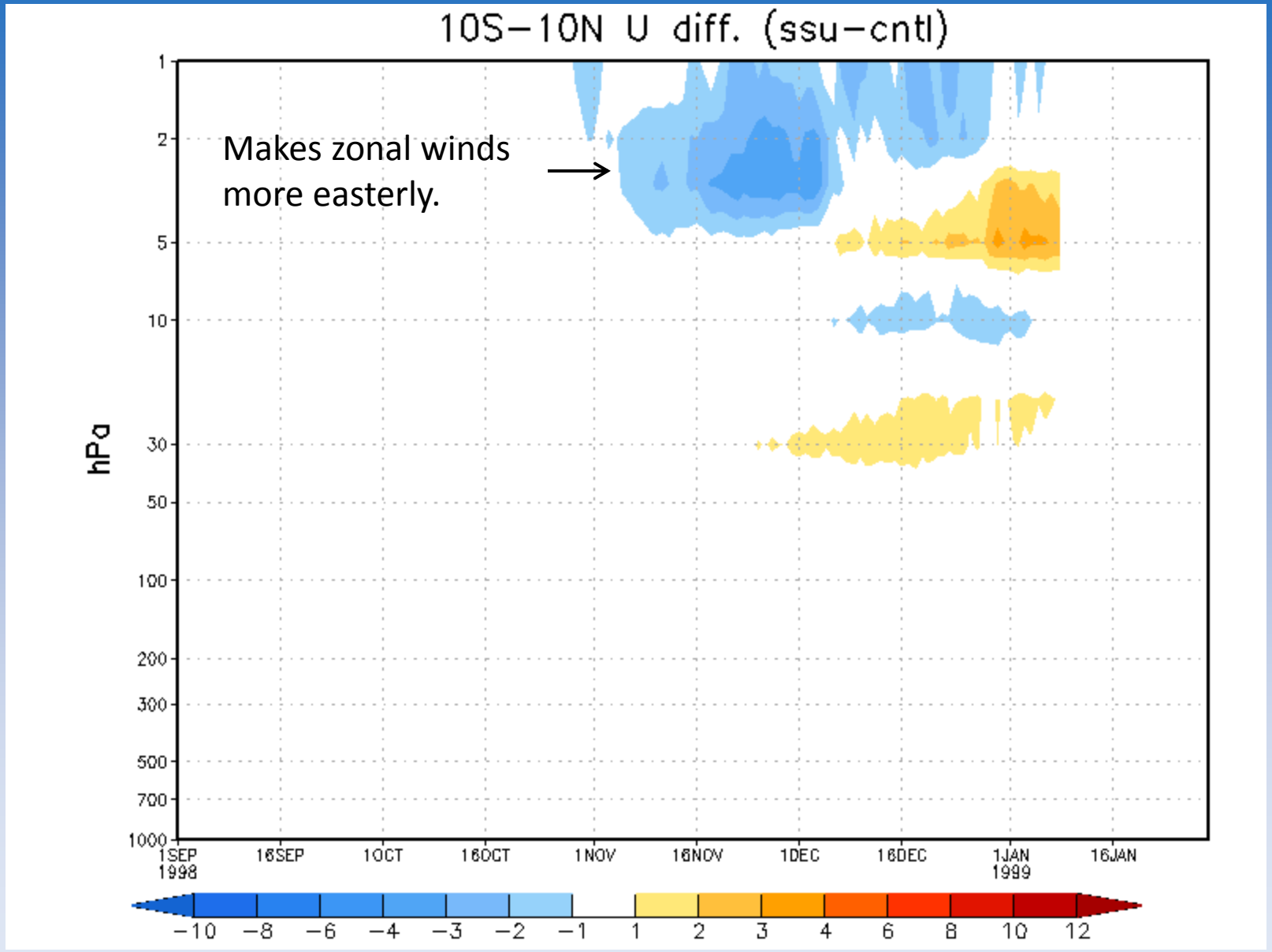

60S–90S T diff. (ssu – cntl)
hPa
1
2
5
10
30
50
100
200
300
500
700
1000
1SEP 1998
16SEP
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC
1JAN 1999
16JAN
−1.6 −1.4 −1.2 −1 −0.8 −0.6 −0.4 −0.2 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6



SSU&AMSU colder than AMSU alone

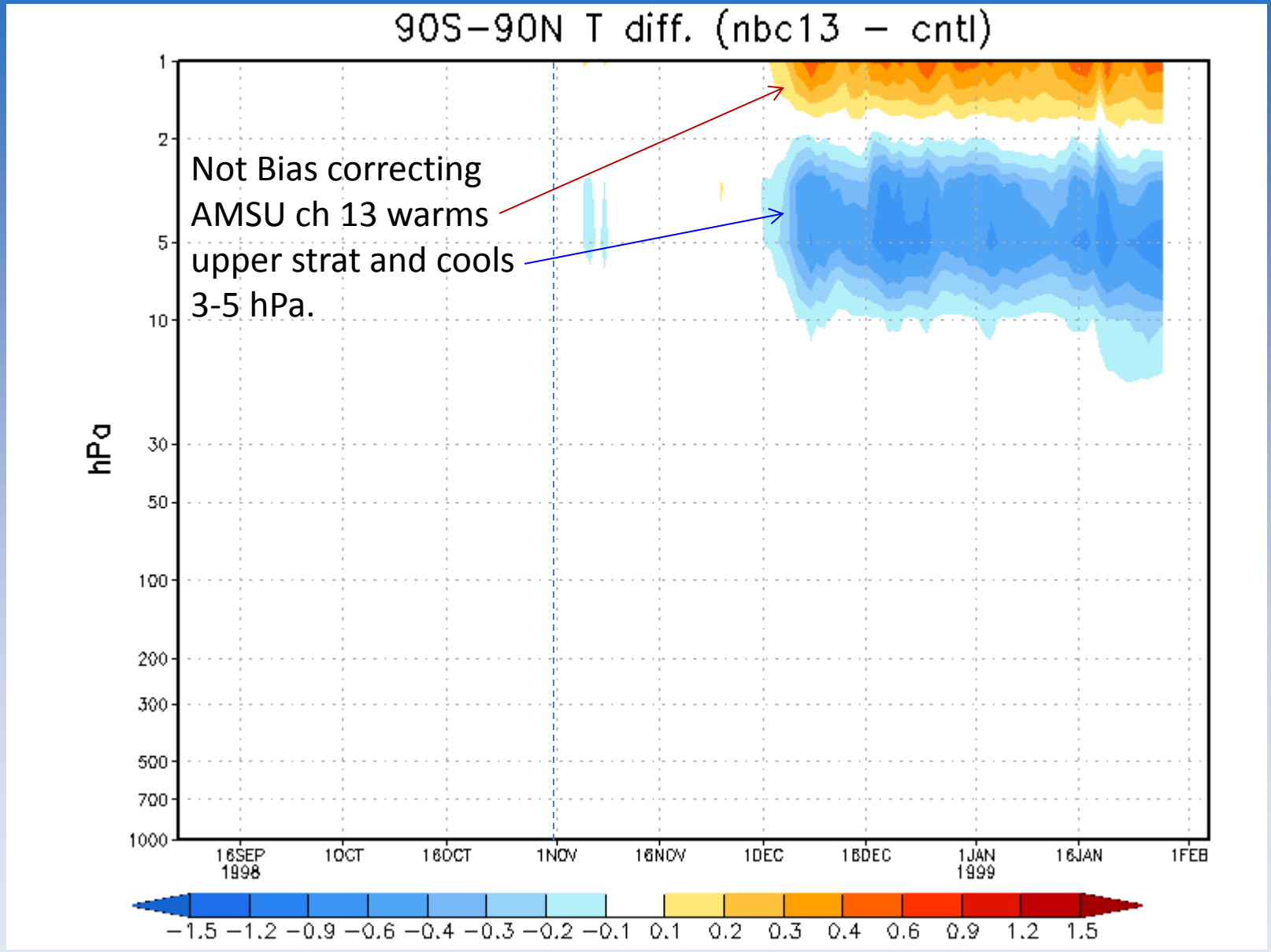


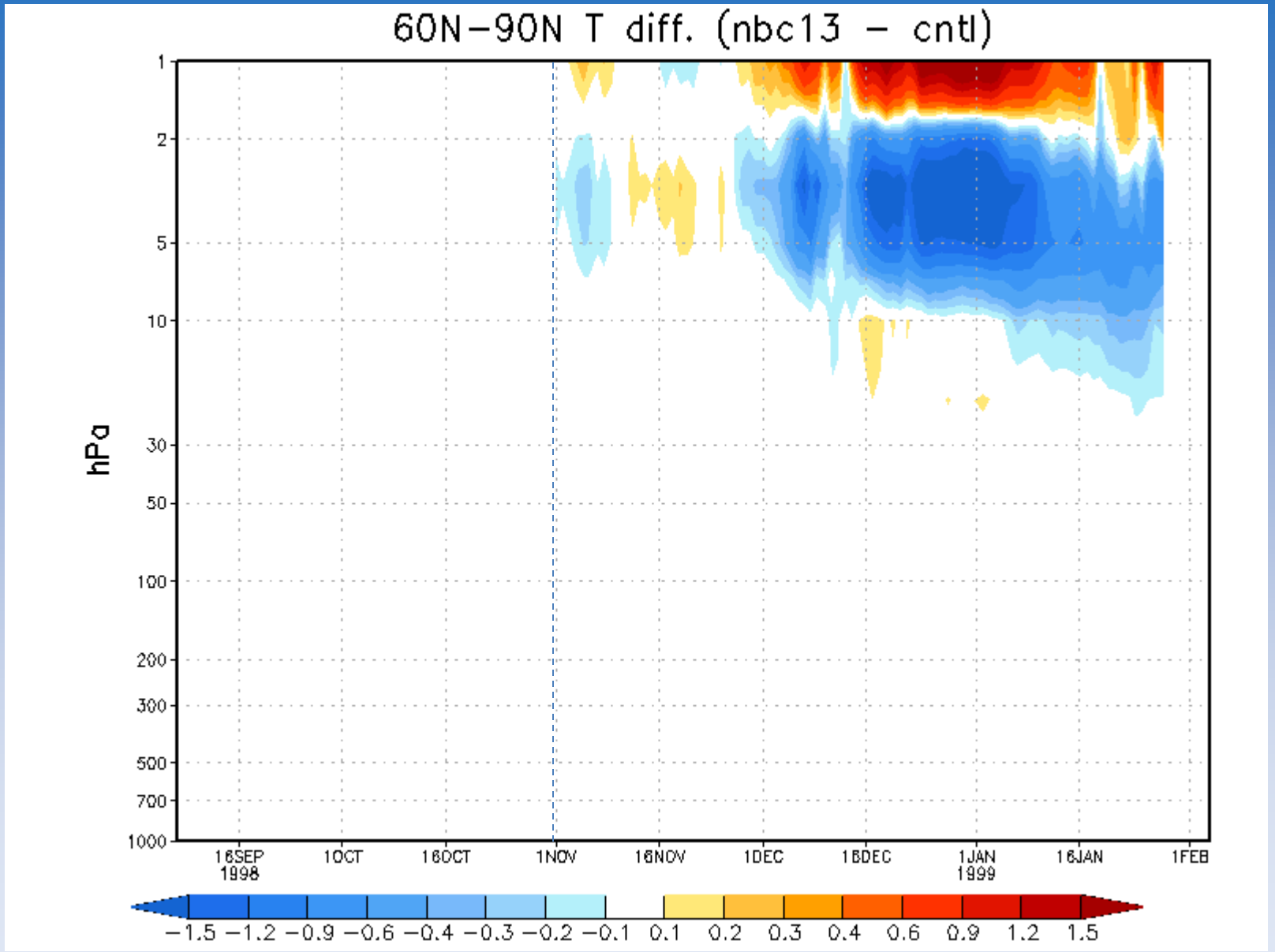
SSU&AMSU warmer than AMSU alone

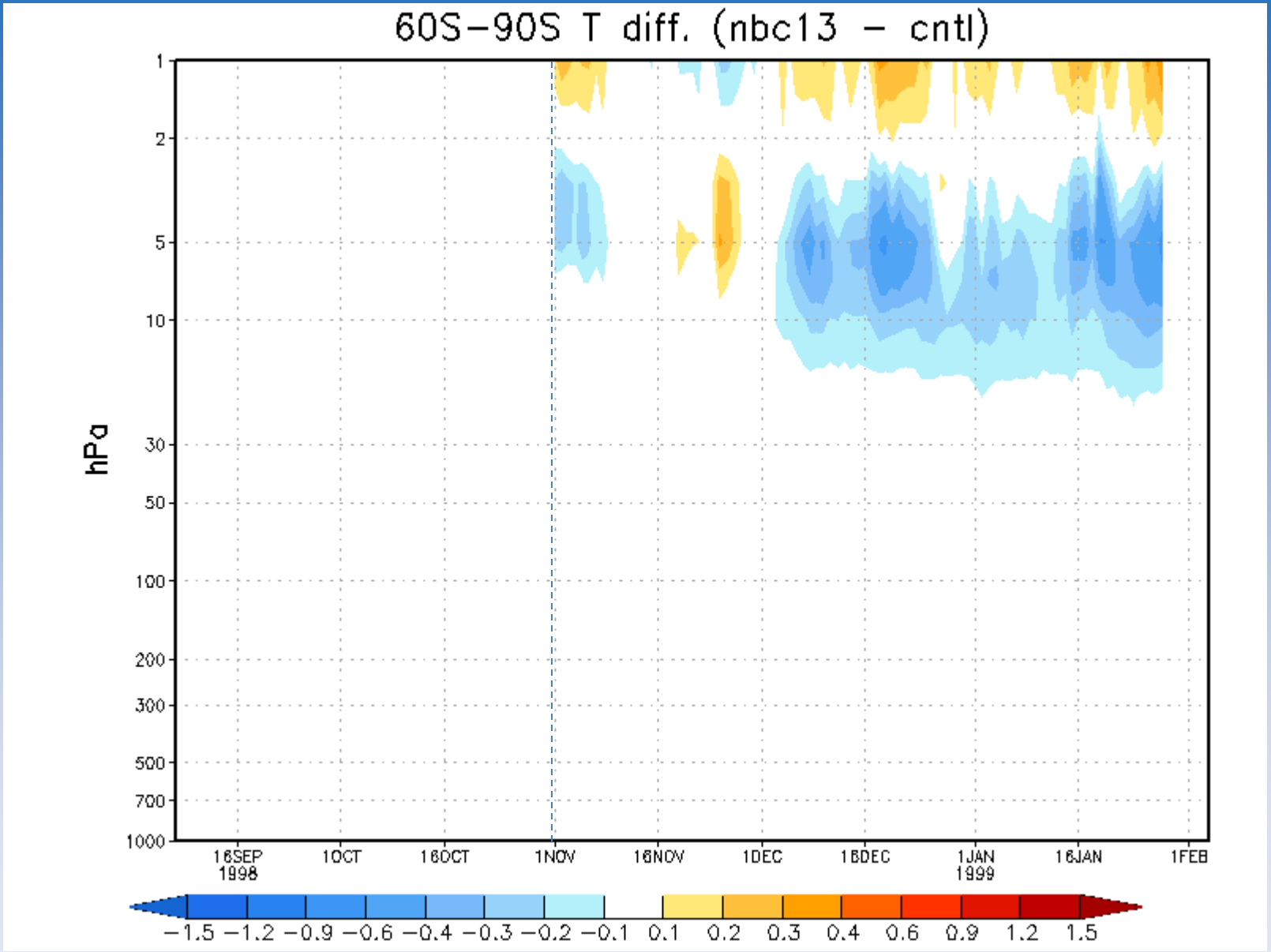

10S–10N U diff. (ssu–cntl)
Makes zonal winds more easterly.
hPa
1
2
5
10
30
50
100
200
300
500
700
1000
1SEP 1998
16SEP
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC
1JAN 1999
16JAN
−10 −8 −6 −4 −3 −2 −1 1 2 3 4 6 8 10 12

Experiment with no bias correction of AMSU channel 13

- **Cntl (pr1998o): AMSU channel 13 bias corrected**
- **Nbc13 (pr1998c): AMSU channel 13 not bias corrected**
- **Initiated 1998/11/01/00**
- **Ozone is assimilated in both cntl and nbc13**


90S-90N T diff. (nbc13 - cntl)
Not Bias correcting
AMSU ch 13 warms
upper strat and cools
3-5 hPa.
hPa
1
2
5
10
30
50
100
200
300
500
700
1000
16SEP 1998
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC
1JAN 1999
16JAN
1FEB
-1.5 -1.2 -0.9 -0.6 -0.4 -0.3 -0.2 -0.1 0.1 0.2 0.3 0.4 0.6 0.9 1.2 1.5


60N−90N T diff. (nbc13 − cntl)
hPa
1
2
5
10
30
50
100
200
300
500
700
1000
16SEP 1998
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC
1JAN 1999
16JAN
1FEB
−1.5 −1.2 −0.9 −0.6 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.6 0.9 1.2 1.5

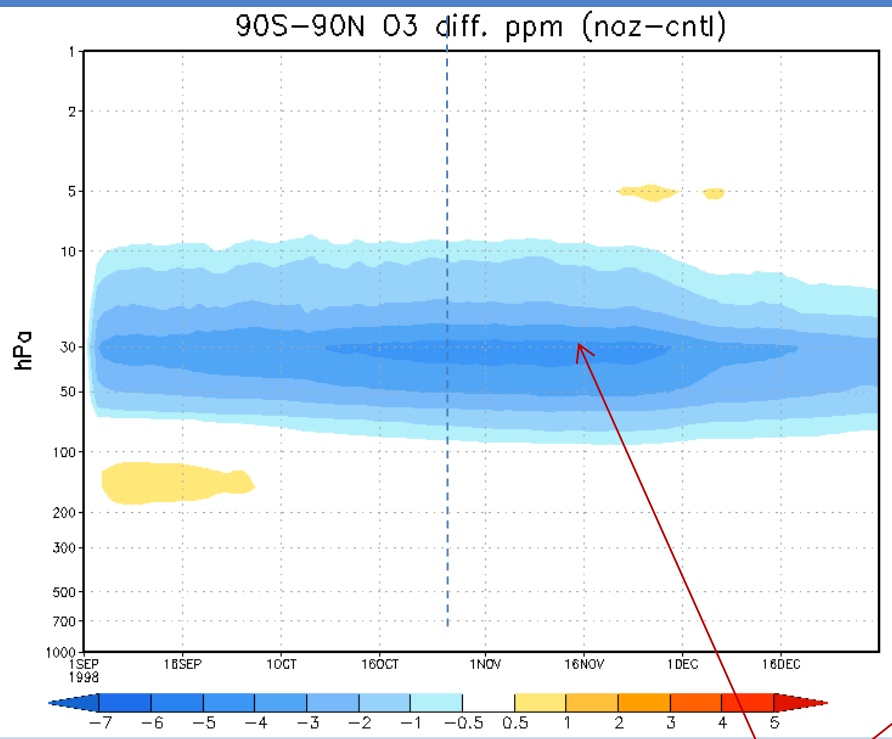

60S-90S T diff. (nbc13 - cntl)
hPa
1
2
5
10
30
50
100
200
300
500
700
1000
16SEP 1998
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC
1JAN 1999
16JAN
1FEB
-1.5 -1.2 -0.9 -0.6 -0.4 -0.3 -0.2 -0.1 0.1 0.2 0.3 0.4 0.6 0.9 1.2 1.5

Impact of no ozone data assimilation

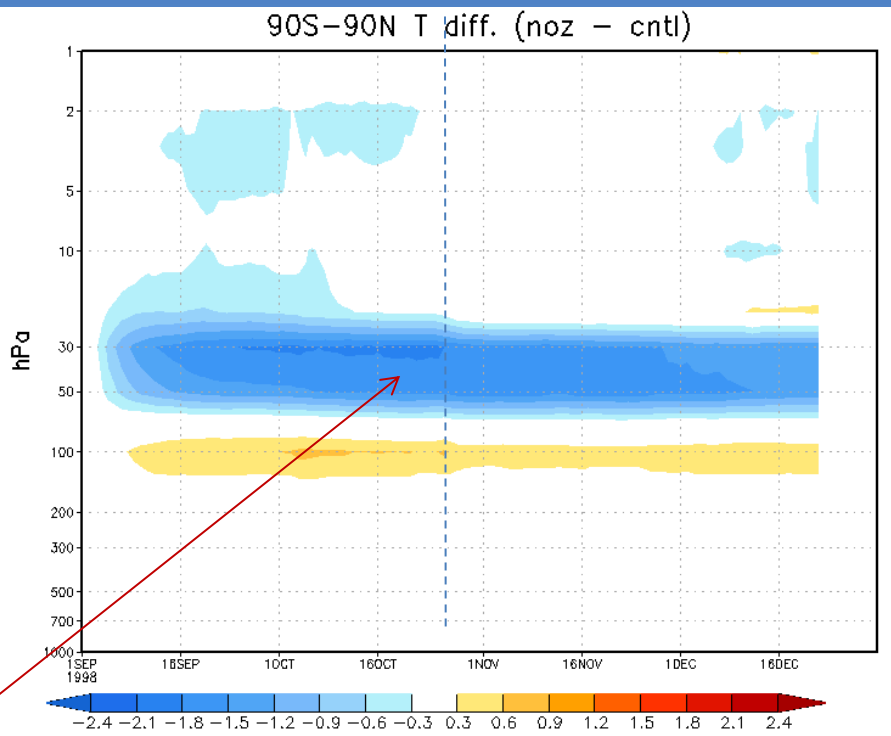
- **cntl: With ozone data assimilated (pr1998o)**
- **noz: Without ozone data assimilated (pr1998b)**
- **Both exps switch SSU to AMSU in 1998102600**

Global

O3mr Diff



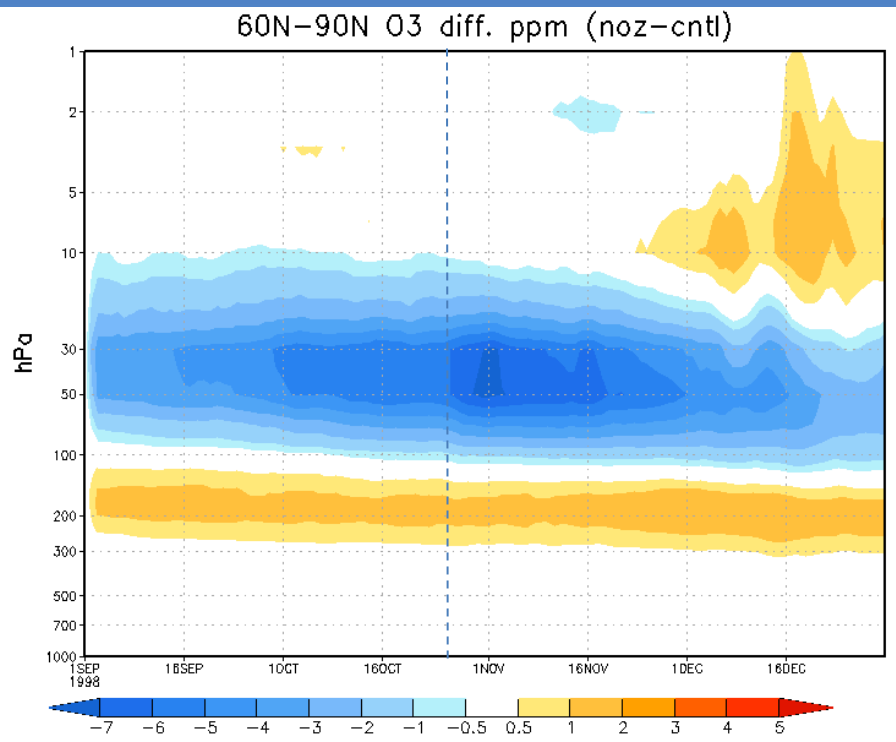
Temp Diff



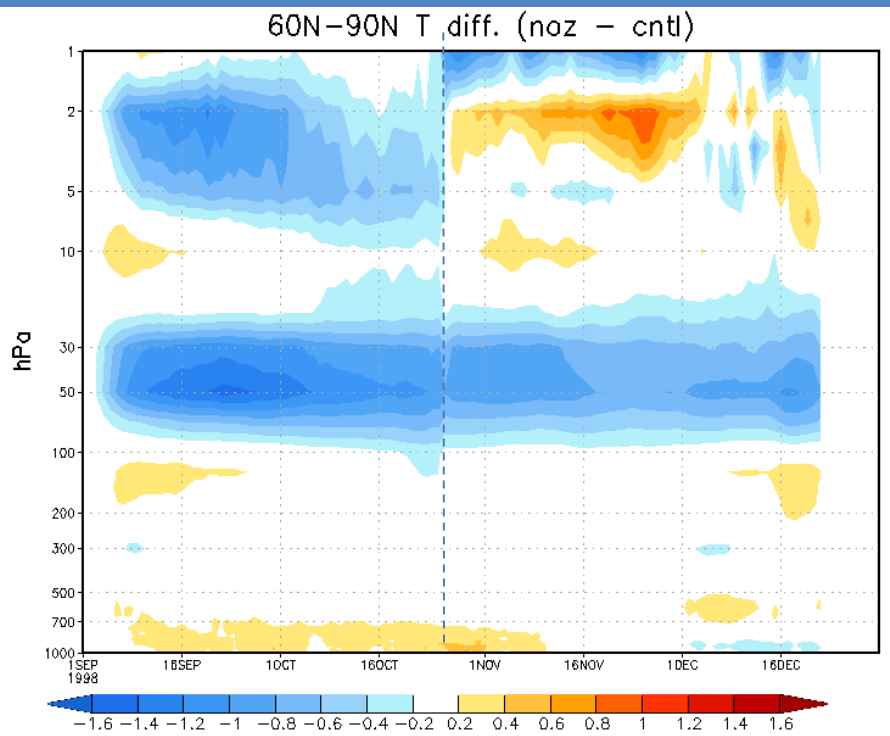
Less ozone in the lower stratosphere results in cooler temperature.
Slight warmer temps at or below tropopause.

60N-90N

O3mr Diff

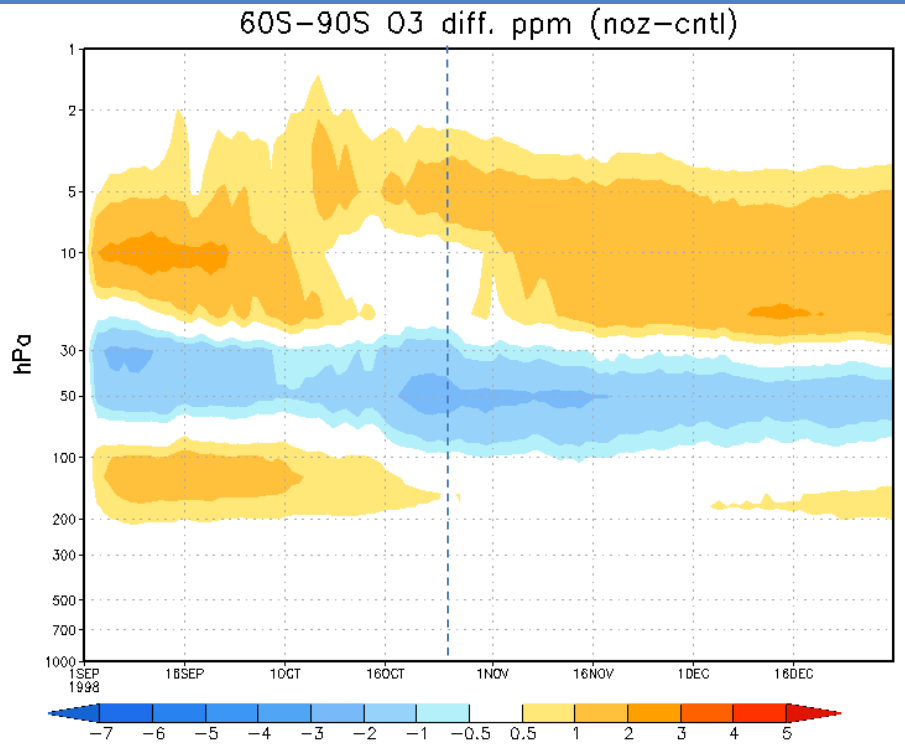


Temp Diff

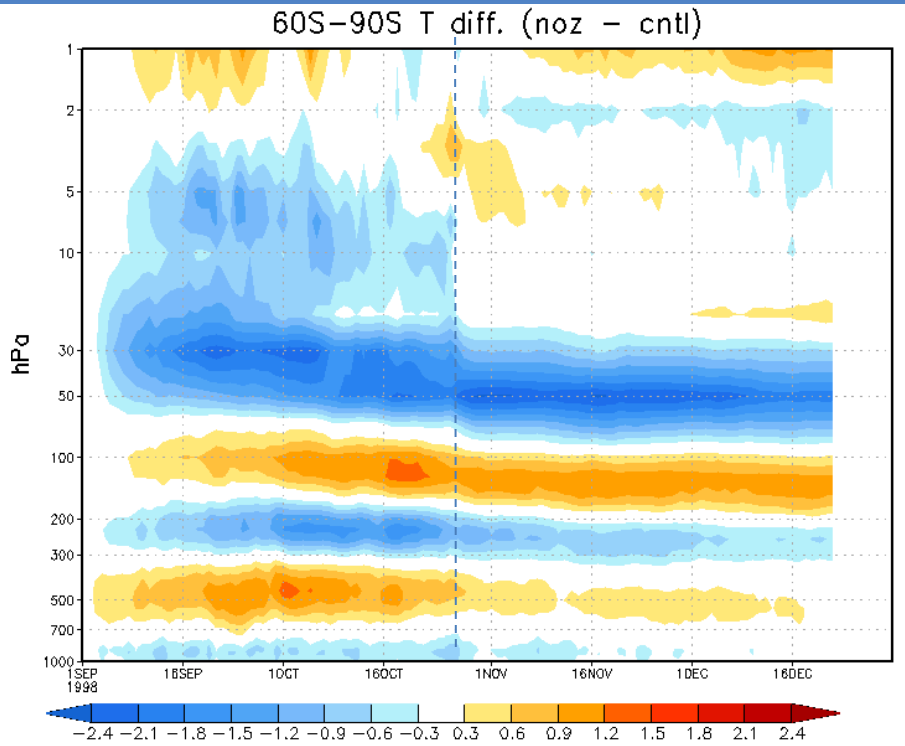


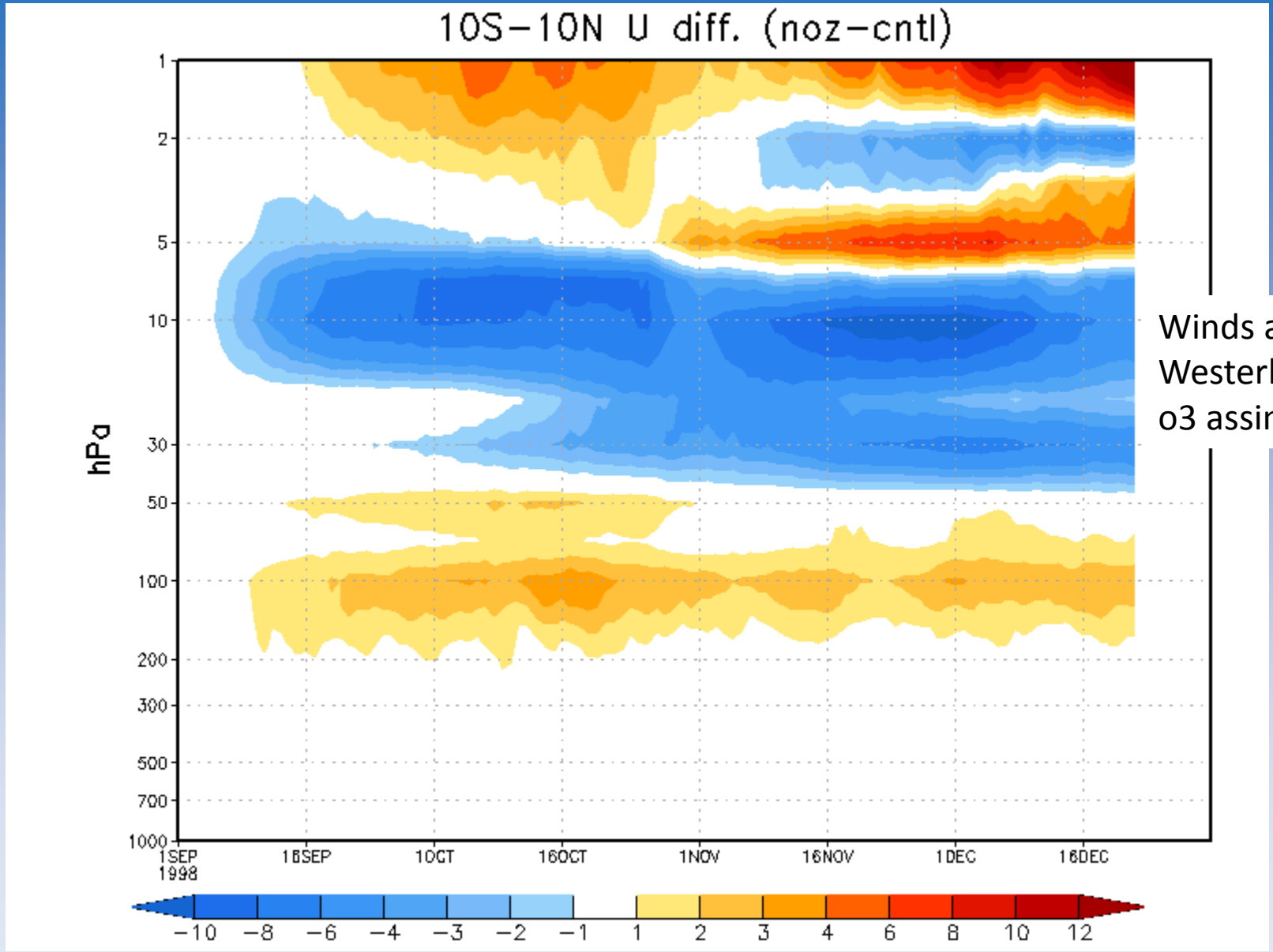
60S-90S

O3mr Diff



Temp Diff

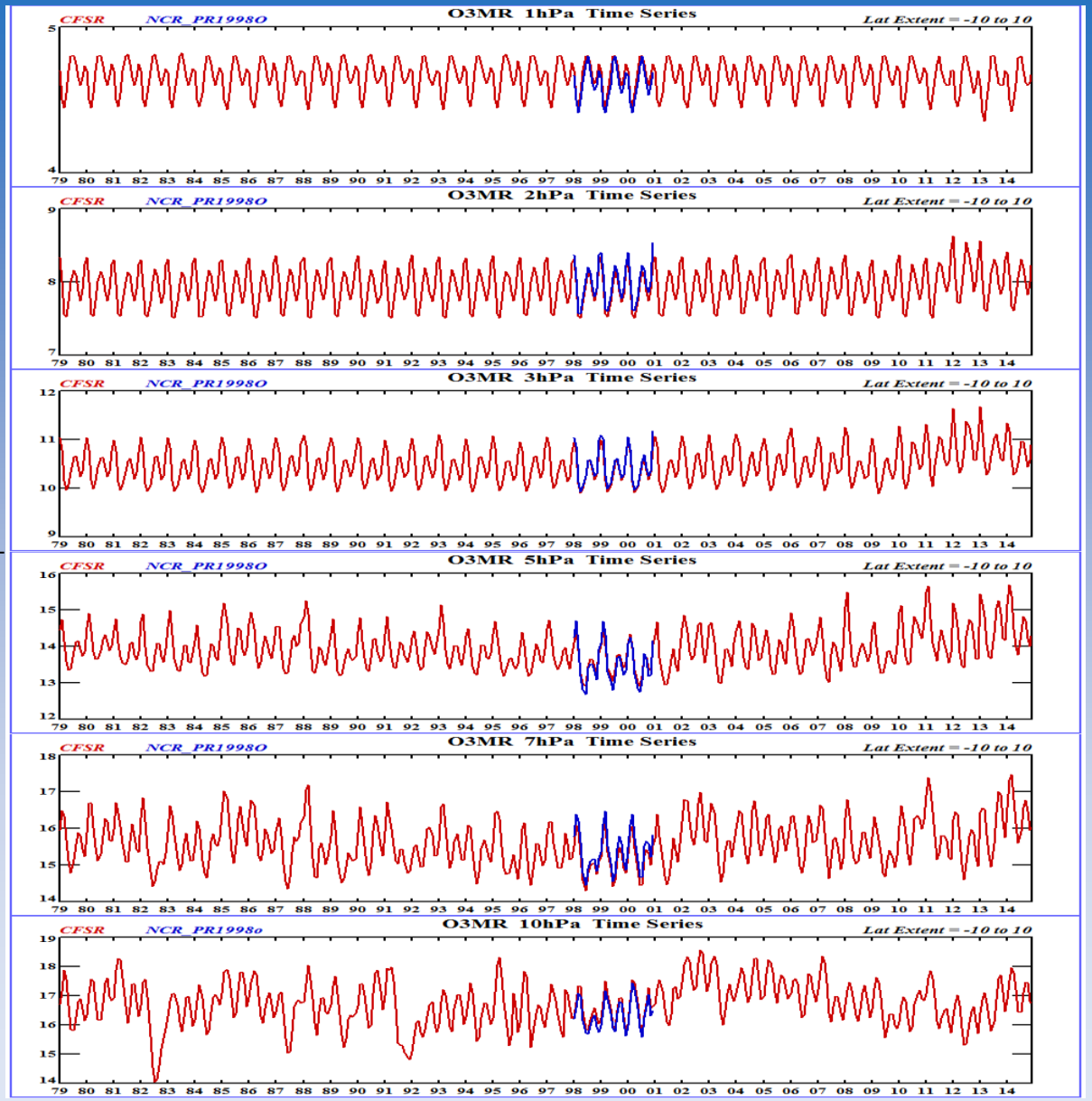




Winds are more Westerly with o3 assimilation

Repeating O3mr Seasonal Cycle In Upper Stratosphere

10S-10N



Red is CFSR

Blue is 3 year test run.

No inter-annual variability

Inter-annual variability

CFSR and test run only assimilate SBUV/2 o3mr.

Summary

- Assimilation of Ch 14 makes temps in upper strat agree with MERRA.
- Not bias correcting SSU ch 3 results in cooler temps in upper strat at end of stream prior to switch from TOVS to ATOVS.
- Assimilation of both SSU and AMSU post 1998 cools upper strat (1-2 hPa) and warms at 3-7 hPa.
- Not bias correcting AMSU ch 13 warms 1-2 hPa by as much as 1° and cools 3-7 hPa by as much as 1°.
- In GFS/CSFR assimilation of ozone impacts temps in lower strat making them as much as 2° cooler and warming upper trop by 0.5°
- Assimilation of ozone impacts ozone amounts in polar latitudes (especially SH during ozone hole months). Impacts temps during that time.
- Repeating ozone in upper strat not a result of obs errors.
- Most likely due to P+L terms driving seasonal cycle and dominate observed ozone amounts.